## REMARKS

This paper is presented in response to the non-final official action dated July 29, 2011, wherein (a) claims 1-26 and 29-44 were pending, (b) claims 1-15, 39, and 40 were withdrawn from consideration, (c) the previous rejections were all withdrawn in view of the applicant's amendments; (d) claims 16-26, 29, 30 32-36, 38, and 41-43 were newly rejected on basis that the claimed subject matter would have been obvious in view of the five-way combination of Nakata (EP 0940860), Probst (US 5,626,688), Wendt (US 6,310,281), Levine (US 4,407,320), and Yoshikawa (US 6,586,670); (e) claim 31 was newly rejected on basis that the claimed subject matter would have been obvious in view of the six-way combination of the references previously mentioned together with Hogel (US 4,913,744); and (f) claims 37 and 44 were newly rejected on basis that the claimed subject matter would have been obvious in view of the six-way combination of Nakata, Probst, Wendt, Levine, and Yoshikawa, together with Tsuzuki (US 5,679,176).

By the foregoing, new claim 45 is presented, and is directed to embodiments wherein the conductive front contact layer comprising a transparent conductive oxide (TCO) is a deposited layer on the support layer and conductive elements, support being found on page 12, line 19, of the original application.

Claims 16-26, 29-38 and 41-45 are at issue, with claim 16 being independent.

Reconsideration of the application, as amended, is solicited.

The issues raised in the official action are addressed below in the order in which they appear in the action.

***Claim Rejections – 35 USC 103***

Claims 16-26, 29, 30 32-36, 38, and 41-43 were newly rejected on basis that the claimed subject matter would have been obvious in view of the five-way combination of Nakata (EP 0940860), Probst (US 5,626,688), Wendt (US 6,310,281), Levine (US 4,407,320), and Yoshikawa (US 6,586,670). Claim 31 was newly rejected on basis that the claimed subject matter would have been obvious in view of the six-way combination of the references previously mentioned together with Hogel (US 4,913,744). Claims 37 and 44 were newly rejected on basis that the claimed subject matter would have been obvious in view of the six-way combination of Nakata, Probst, Wendt, Levine, and Yoshikawa, together with Tsuzuki (US 5,679,176).

The rejected claims are respectfully traversed, and reconsideration is requested. All claim rejections rely on a combination of combination of Nakata, Probst, Wendt, Levine, and Yoshikawa, which is traversed below. Upon acceptance of the applicant's arguments below, all claims should be considered to be in condition for allowance.

Nakata describes spherical semiconductor elements with CIS according to the examiner's opinion. Probst discloses a molybdenum back contact according to the examiners opinion. Probst and Wendt disclose that glass may be a suitable substrate for CIS according to the examiner's opinion. Levine describes a serial connection of spherical semiconductor elements embedded in an aluminum foil. Yoshikawa discloses that aluminum and TCOs may be used as electrically conductive materials in solar cells.

In this respect, the official action takes the position that it would have been obvious to replace the aluminum foil of the serial connection described in Levine with a TCO layer described in Yoshikawa to get to the present invention, since both materials are art-recognized equivalents in the examiner's view.

It was previously argued that despite that both aluminum and TCO layers are both electrically conductive materials that may be used in solar cells (as shown in Yoshikawa), they are absolutely not universally equivalent materials and may not simply be replaced one by another in any application without further ado, as alleged

by the official action, since they have completely different properties and especially mechanical properties. It is respectfully submitted that in the present circumstances, concerning the prior art at issue, there would be no expectation of success in making the modification proposed by the Office, substituting a TCO for the aluminum layer of Levine.

Concerning this argument, the examiner has stated that the mere allegation of different properties is not convincing and that Kuo US 5,356,656 shows that TCO layers may be also used for flexible solar cells.

We would like to note that the properties and especially the mechanical properties of an aluminum foil and a TCO layer are indeed very different. This is not merely an allegation as considered by the examiner.

First of all, it may be noted that aluminum is ductile and may be transformed into foils, which are as such manipulabe individual/stand-alone elements. This is not possible with TCOs. They simply cannot be transformed into stand-alone foils. They can rather be only deposited as thin layers on a substrate. The reason therefore is obviously the very different mechanical properties of aluminum and TCOs. This is a first important and fundamental difference. If the examiner believes that this is a mere allegation, she is kindly requested to explain how stand-alone TCO foils may be obtained.

Moreover, this difference in properties means that in view of the serial connection arrangement described in Levine, which relies on spherical semiconductor elements embedded in the holes of a stand-alone, perforated 2 mil thick aluminum foil, someone skilled in the art will not consider replacing the said stand-alone perforated 2 mil thick aluminum foil of Levine with a TCO layer without further ado, since this is simply and plainly impossible. A perforated standalone TCO foil which can simply replace the aluminum foil used in Levine actually cannot be obtained. Accordingly, there is plainly no way to just replace aluminum with TCOs without further ado in Levine. There would be no expectation of success in making the simple substitution alleged by the Office.

Further it has to be noted that in contrast to simply replacing art based equivalents one by another without further ado as suggested by the Office, the whole arrangement of Levine would have to be completely modified to even allow the use

of TCOs instead of aluminum. This is required because despite being both electrically conductive aluminum and TCOs are absolutely not equivalent materials, rather they are completely different materials with different properties.

The mere indication that TCOs may be used in flexible solar cells (see Kuo) does also not change the fact that TCOs and aluminum have indeed very different properties and especially mechanical properties.

This may be further supported by the fact the aluminum and for example ITO (as an example of a TCO) have different values for Young's Modulus (70 Gpa for aluminum and 116 Gpa for ITO, see *Thin Solid Films* 278, 1-2, 12-17, 1995) and also completely different values for the breaking strain (at least 7% for aluminum and only 0.003 to 0.022 % for ITO, see *MRS Symp. Proc.,* 666, F3.24.1 -12, 2001). The huge difference for the breaking strain further shows that these materials are indeed completely different regarding their mechanical properties.

Furthermore, aluminum and ITO, as an example of a TCO, have very different thermal expansion coefficients ($23.1 \times 10^{-6}$ $K^{-1}$ for aluminum and $8.5 — 10.2 \times 10^{-6}$ $K^{-1}$ for ITO, see *Thin Solid Films*, 288, 176, 1996).

All this shows that aluminum and TCOs (despite being both electrically conductive) are actually completely different materials with different properties, which may not simply be replaced one by another without further ado. Moreoever, the foregoing shows that in contrast to the examiner's opinion, the different properties of TCOs, e.g. ITO, and aluminum are not a mere allegation.

In view of the disclosure of Levine with recites a perforated aluminum foil and of the actual differences between aluminum and TCOs as materials, especially concerning the properties, these materials may not be considered as substitutable equivalents, which may be replaced one by another without further ado in the device of Levine, in contrast to the examiners opinion.

If starting from Levine one would consider using TCOs in place of aluminum, one would rather have to face various potential problems.

Since it is simply not possible to get perforated TCO foils to replace the aluminum foil, one would have to consider the use of a substrate for the TCO layer. This substrate would however further complicate the system and also influence/change the properties of the TCO layer.

Even if one would consider using a TCO layer on a substrate, one would thus have to select an appropriate substrate, without there being any indication in the prior art about a suitable substrate for the specific use in an arrangement according to Levine.

One would also have to figure out how to ensure perforation.

It also may be noted that the perforation of the substrate before applying the TCO layer may lead to problems, since the holes may be obstructed or even completely closed by the deposited TCO layer. This could hinder the semiconductor spheres to properly enter the holes to get the serial connection.

On the other hand, performing perforation after the application of the TCO layer to the substrate may lead to damaging the TCO layer especially at the edges of the holes (where mechanical constrains are applied during perforation). The edges of the holes are thereby of the utmost importance, since contact with the semiconductor spheres is established at these edges.

Whether a deposited TCO layer would be suitable and how it would actually behave without the benefit of the present invention is thereby merely pure speculation, as there is no hint thereto in the prior art. (E.g., will it close the holes if applied after perforation or will it be damaged by perforation after the application?) It would rather require a lot of experimentation to find out if and how the aluminum foil may at all be replaced by a TCO layer.

It does therefore not appear how someone would arrive at the presently-claimed invention based on the prior art in view of the explanations above concerning actual differences between the two materials. If the Office however still believes that replacing the perforated aluminum foil with a TCO would have been obvious, it is kindly requested to present a convincing line of reasoning accounting the difference between the materials explained above.

Even so, starting from Levine and combining with Yoshikawa to use TCOs instead of the aluminum foil, one would at the very best result in a perforated TCO/substrate layer with semiconductor elements embedded in this perforated layer.

This, however, is not the present invention.

The inventors have rather solved the above mentioned problems (related to the fact that no stand-alone TCO layer may be obtained and also related to

perforation) by embedding the semiconducting spheres in a polymer layer (by pushing them in the soft polymer without any additional perforation step) and by providing a continuous conductive TCO layer on top of this polymer substrate with embedded semiconductor elements (without any perforation of the conductive TCO layer at all).

It must be noted that there is no hint toward avoiding the perforation of the conductive layer in the prior art.

Rather, it should be noted that Levine explicitly teaches the use of a perforated conductive layer (perforated aluminum foil) and thus actually explicitly leads away from the arrangement according to the present invention.

It is thus noteworthy that there is absolutely no hint toward such an arrangement as claimed in the prior art.

New claim 45 is presented, and is directed to embodiments wherein the conductive front contact layer comprising a transparent conductive oxide (TCO) is a deposited layer on the support layer and conductive elements, to make the difference with perforated layers even clearer.

Beside of this, it should also be noted that Levine describes silicon spheres contacted with an aluminum foil, whereas the present invention deals with CIS on glass spheres contacted with a TCO layer on an insulating substrate into which the conductive elements are incorporated in a protruding fashion, such as a polymer support, e.g. thermoplastic PET.

There is no indication in the prior art that a CIS layer on glass spheres may be contacted with a TCO (for example a TCO layer) layer on a such a substrate without any problems given the different thermal expansion coefficients involved.

The thermal expansion coefficients are thereby 8.5 — 10.2 x $10^{-6}$ $K^{-1}$ for ITO as an example of a TCO layer (see *Thin Solid Films*, 288, 176, 1996), 8-11 x $10^{-6}$ $K^{-1}$ for CIS and 60-65 x $10^{-6}$ $K^{-1}$ for a polymer substrate like for example polyester/PET.

This means that while the thermal expansion coefficient of CIS and ITO seems to match well, the thermal expansion coefficient of the polymer used as a substrate for the ITO is extremely different.

The inventors thought that these differences concerning the thermal expansion coefficient could lead to problems.

When heated especially for example by direct insulation (during the actual use of the solar cells) the polymer substrate and the ITO expend in a radically different way one from another.

This may obviously lead to potential problems including material stress (upon each heating and subsequent cooling), material fatigue and ultimately damage to the TCO layer (during years of rather periodic insulation when used as solar cells).

However, in practice this works surprisingly well and does not lead to problems at all despite the different thermal expansion coefficients. This could not be expected and it is not yet fully understood. This has to be considered as surprising.

This again supports that getting to the present invention was actually not obvious and straight forwarded but actually required experimentation with quite surprising results. The present invention thus would not have been obvious in view of the prior art.

***Conclusion***

For all the foregoing reasons, all elected claims 16-26, 29-38 and 41-45 are of proper form and scope for allowance, and such action is solicited.

Should the examiner wish to discuss the foregoing or any matter of form in an effort to advance this application toward allowance, she is urged to telephone the undersigned at the indicated number.

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